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A CONFERENCE ON TSUNAMI PROBLEM AT U.S.S.R. -By S.L. Soloviev

A conference on tsunami problems convened by the Tsunami Commission of the Interdepartmental Seismology and Seismic-Resistant Construction Council of the Presidium of the USSR Academy of Sciences was held in Moscow on May 16 and 17, 1968. This was the fourth conference of its kind. Previous ones were held in Moscow in 1953 (1), in Yuzhno-Sakhalinsk in 1957 (2, 3) and in 1965 (4, 5). The conference was attended by about 40 representatives of different institutes of the Academy of Sciences, Hydrometeorological Service, and organizations dealing with the tsunami warning service. Ten scientific reports on work related to the tsunami problem were presented.

A review of research on the theory of tsunami waves, carried out at the Oceanology Institute of the USSR Academy of Sciences during recent years, was made by S.S. Voit and B.I. Sebekin. Operator methods were used by the authors to solve the problem of wave generation from different kinds of disturbances. Transmissive function constructions for a wide class of problems both in unlimited basins and in basins with cylindrical obstacles were indicated. In particular, the report offered a solution for waves excited by a source acting within the ocean thickness according to arbitrary law. Another aspect of the research dealt with the study of long wave propagation when the wave characteristics along the wave fronts are known. In particular, the report offered a solution to the problem of dispersive long waves in an open basin.

The report "Some Hydrodynamic Problems of Tsunami Waves" by L.V. Cherkesov (Marine Hydrophysical Institute of the USSR Academy of Sciences) offered results of studies on the influence of viscosity and the jump in density of waves excited by submarine disturbances. It was shown that viscosity favors the origin of a small ebb preceding the arrival of the tsunami waves. It was also shown that a jump in density and a sharp change of the basin floor slope together constitute a sufficient cause to set up secondary tsunami waves.

The report "Kinematics and Dynamics of Reflected and Refracted Tsunami Waves Generated on Rectilinear Floor Scarps" was made by V.A. Bernstein (Sakhalin Complex Research Institute of the Siberian Branch of the USSR Academy of Sciences). The propagation of small amplitude long gravity waves in a flat rotating basin with a stepped floor was investigated. A model was constructed and waves were generated by an impulsive point source. Final solution was reached by means of integral transformations for low and high values of kt where k is the Coriolis parameter and t is the time. It was shown that at high kt values specific Kelvin-Poincare waves result from the basin rotation. The decrease in the amplitude of these waves along a step corresponds to the case of plane waves propagating along a step, i.e., it is much slower than for usual reflected and refracted waves. The decrease in the amplitude of reflected waves with time is also much slower than that of refracted ones. In the case of a remote tsunami source and a great depth difference on both sides of a step, Kelvin-Poincare waves may reach considerable development and may possibly be forerunners of the main tsunami wave.

The report "Excitation of Tsunamis by an Earthquake" by Podyapolsky (Institute of Physics of the Earth of the USSR Academy of Sciences) offers some additional clarifications to a previously published paper of his on the tsunami generation problem. In this report the approximate solution obtained for the gravitational wave is equivalent to the consecutive solution of the following two problems: 1) the problem of a source in a free surface elastic semi-space being solved in a quasi-static way; 2) Yu.L. Gazaryan's problem for movement in a layer of an uncompressible liquid along a solid basement with a given floor movement, obtained from the solution of the preceding problem. Some preliminary computer results of excited gravity waves were presented. Emphasis was placed on the fact that the effect of the optimum "tsunamibility" depth of a source was determined for the harmonic component of perturbation and with transition into impulse perturbation by way of summation of individual phases.

In the report "Recurrence of Tsunamis in the Pacific Ocean and Correlation of Seismic and Tsunami Activity," S.L. Soloviev and CH.N. Go (Sakhalin Complex Res. Inst.) presented the results of their summarization of facts about Pacific tsunamis; the results are as follows: A catalogue of the Pacific tsunamis has been compiled. The intensities of the tsunamis have been estimated by the modified Imamura-Iida scale and the tsunami foci have been localized. A chart of the hypocenters in the Pacific Ocean has been constructed. It has been deduced that the probability of generation of tsunami waves by an earthquake may vary four-fold depending on the peculiarities of zone structures. On the average, the probability of generation of tsunami intensity varies from 0 to I, the earthquake magnitude varying roughly from $6\frac{1}{2}$ to $8\frac{1}{2}$. Probability curves of tsunami intensity have been derived based on earthquake magnitude.

In his report "Division of Tsunami Regionalization for the Pacific Coast of Kamchatka and Kuril Islands," A.N. Kashcheyev (State Hydrology Institute) considered a two-dimensional problem of tsunami wave propagation with regard to the bottom relief, Coriolis Forces, friction at the bottom, and viscosity. Using numerical methods, an approximate solution to the problem was obtained. The method used for deriving wave rays took refraction into account, and a satisfactory agreement between computational and observational data was obtained. The author also considered the problem of reflections of waves from high sub-

marine features and from the shelf's edge. The height of water runup and the time of tsunami arrival at all the coastal points were estimated by computer. The coast was divided into regions according to the degree of tsunami danger on the basis of the computations and utilizing the existing observations. Consequently, the Pacific Coast of Kamchatka and Kuril Islands have been divided into 13 regions according to the degree of tsunami danger The establishment of new seismic and tide gage stations was recommended.

The report "On the Influence of Refraction on Tsunami Wave Propagation," R.V. Yaroshenya (Far East Hydrometeorology Res. Inst.), compiled results of long-term work in deriving ray schemes of tsunami propagation from different point sources of the Kuril-Kamchatka seismic zone. The Pacific coast of Kamchatka and Kuril Islands have been divided into regions according to the degree of tsunami intensity which varies due to the peculiarities of the ocean floor relief between the tsunami sources and the coastline.

Six regions have been outlined: 1) Kamchatka and Kronotsky Bays, 2) the Shipunsky peninsula, 3) the South Kamchatka district, 4) the North Kuril district, 5) the islands of Rasshua, Ketoy, Simushir, and 6) the South Kuril district. Ray patterns are generally simple in regions 2, 3, 4, 6, and complex in regions 1, 5. The rays radiate along the axes of submarine trenches transverse to the coastline, and converge along the axis of transversal mountain ranges, accounting for the variation in the intensity of the tsunamis at corresponding parts of the coastline.

The report "Laboratory Studies and Computation of Tsunami Wave Transformation in Shallow Waters and on a Dry Shore" by M.I. Krivoshei (State Hydrology Inst.) presented results of modeling and computation of tsunami movement in a 100-meter chute. The wave height did not change in the constant depth zone adjacent to the source, but the wave steepness grew and secondary oscillations were formed at some distance from the source. These were called "undulations." A hypothesis has been suggested that the run-up tsunami waves are such undulations. The results of modeling readily agree with the computations of the undulation profile of a tsunami. Non-linear shallow water equations solved by the method of characteristics were used for computations in the zone of constant depth. The computation on the collapse of undulations and their bore-like movement towards the water edge were carried out by the method of discontinuous wave computation, i.e., using the hydraulic jump equation. Special attention was given to the conditions to the edge, and particularly to the method of flow velocity computation. The computation of runup of a wave on the shore was carried out by means of integration of Newton's second law with regard to gravity, inertia and friction forces. Two relationships were suggested for the computation of the lead edge of a flow on a shore, one of the two relationships being deduced from the discontinuous wave equation, the other from the continuous equation.

The report "Studies of Flow Structure as an Overflow of Waves" by A.E. Reichrudel (Faculty of Physics, Moscow State University) dealt with experimental studies of the interaction of a single wave with an obstacle having a trapezoid section along the path of the flow. The geometrical dimensions of the trapezium varied as follows: the slope angle from 5 to 90°, the height of the trapezium from 22 to 32 cm, the length of the horizontal part from 12 to 100 cm. The transformation

of a single wave as it moved up the slope and ran over the obstacle was recorded by a motion picture camera. Data was obtained on the change of wave height as it moved towards decreasing depths and up the shore; on the wave velocities on the slope and on the trajectory of neutral buoyancy particles; on the magnitude of vertical and horizontal components of the velocity vector of the particles over the slopes and over the horizontal part of the obstacle. An empirical relationship was obtained for the volume of the water overflowing a sloping obstacle, the height of the horizontal part of the obstacle above the level of a free undisturbed surface, and the length of its horizontal part.

V.M. Zhak gave a short report on the work underway at the Sakhalin Complex Research Institute aimed at creating a remote hydrophysical base of an operational tsunami forecast system.

A paper titled "On the Application of Computers for the Solution of a Problem of Localization of Tsunami Generation" was presented by V.A. Koryakin (Leningrad Higher School of Marine Engineers). He considered methods of localization of a tsunami source from known arrival times of the wave at several (not less than four) observation points with the wave propagation velocity being known.

A detailed report about the state of the tsunami warning service in the Sakhalin region was made by Z.P. Arsentieva (Sakhalin Region Executive Committee). A report on the state of the tsunami warning service in Kamchatka was delivered by L.V. Skripkov (Kamchatka Region Tsunami Committee). G.M. Sokolov (Kamchatka Region Executive Committee) reported on the construction of a new village at Ust-Kamchatsk.

Yu.A. Tarbeyev (Central Hydrometeorological Office) reported on the March 1968 Honolulu session of a special Pacific Tsunami Warning Service Committee set up by the Intergovernmental Oceanographic Commission. M.T. Gladishev (Institute of Hydrodynamics, Siberian Branch, USSR Academy of Sciences) and S.L. Soloviev reported on the Congress of the International Hydraulic Association and the IUGG Tsunami Symposium to be held in 1969 in Kyoto and in Honolulu, respectively.

It was the resolution of the conference that certain progress in the field of solving the theory and tsunami modeling has been made in the USSR. It was also stated that the research in the design of new apparatus for the study of tsunami waves and their forecast is insufficient. It was resolved that it is necessary to speed up the selection of remote hydrophysical stations and to create an adequate scheme of tsunami regionalization for the Pacific coastline of the USSR. Research work should be aimed at the search for additional criteria on the tsunamigeneity of earthquakes and the continuation and development of theoretical and modeling studies. Some indispensible measures of improving the tsunami warning service in USSR were pointed out. Particular emphasis was placed on the necessity for improving the warning system by substantially improving communications, by establishing tsunami stations in Ust-Kamchatsk, and by increasing the number of tide gage stations. These measures would provide better warning for tsunamis in the Japan Sea and for distant Pacific tsunamis. The urgent need to evacuate Ust-Kamchatsk and other communities in the inundation areas during warnings was emphasized.

The conference approved a new membership of the USSR Tsunami Commission and adjourned.

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TSUNAMI MEETING - Xth ASSEMBLY OF THE EUROPEAN SEISMOLOGICAL COMMISSION

During the Xth Assembly of the European Seismological Commission which convened in Leningrad, September 4-11, 1968, a small tsunami meeting took place. The meeting was attended by the following scientists: Dr. P. Bernard, Prof. J.P. Rothe (France), Dr. V.G. Buchteev, Dr. Z.K. Grigorash, Dr. M.I. Krivoshey, Dr. V.A. Makarov (the secretary), A.B. Menzin, Prof. A.E. Ostrovskiy, A.A. Poplavskiy, Dr. R.V. Pyaskovskiy, Prof. E.F. Savarenskiy, and Dr. S.L. Soloviev (the chairman).

The agenda of the meeting included: 1) A discussion of the progress report of the subcommission on tsunamis compiled by Prof. A. Galanopoulos (Greece) and presented by the chairman of the meeting, 2) A discussion of a paper by Z.K. Grigorash and Z.A. Korneva, titled "Tsunamis in the Black Sea," read by Dr. Z.K. Grigorash, and 3) The preparation of a draft on resolutions and recommendations.

Resolution: Participants of the meeting stressed that the preparation of detailed descriptive catalog of European tsunamis, including tsunami mareograms, would be of great scientific and practical importance; asked the chairman of the subcommission to investigate the possibilities of preparing and editing such a catalog on the basis of the existing catalog; appealed to all participants of the compilation of seismicity and seismic zoning maps for Europe to take into account seismo-tectonic and seismic zoning of sea floor areas in order to obtain necessary foundation for future tsunami zoning of the European coasts; and recommended that the chairman and the members of the subcommission be in contact with scientific organizations operating tide gages to try to use these installations for tsunami prediction and investigation.

NEW TSUNAMI PUBLICATION IN SPANISH

Rear Admiral Jorge Camino de la Torre, Director of the Hydrography Department in Peru, informed ITIC that a new publication in Spanish entitled "MAREMOTOS" has been published. The author of this very informative booklet is Rear Admiral Esteban Zimic Vidal. Copies of this publication have already been sent to Ecuador, Colombia, Chile, Mexico and other Spanish-speaking countries of South America. The publication will be of immense support to the Tsunami Warning System because it will familiarize the people of South and Central America with tsunamis and the Tsunami Warning System.

TIDE GAGE INSTALLATION - PAPEETE, TAHITI

Lt. G. Ward of Pacific Tide Party, U.S. Coast & Geodetic Survey, visited Papeete, Tahiti, and assisted in the selection of a site for the installation of a tide gage. The installation of the gage is a joint U.S.-French effort. The gage is expected to be operative in February, 1969.

TEST OF A MID-OCEAN TSUNAMI SENSOR

Preparations are being made to install the COSMOS Platform in the area of the Tongue of the Ocean, near the Bahama Island group. The platform will be used to test satellite telemetry equipment, a tsunami-tide sensor and a unique power supply package.

USSR PARTICIPATES IN TSUNAMI COMMUNICATIONS TEST

On September 15, 1968, a tsunami communications test was made from Khabarovsk, USSR, to Tokyo to ITIC's Honolulu Observatory, with excellent results. Arrangements for this communications test were made in March 1968 at the Intergovernmental Meeting on the Tsunami Warning System in Honolulu.

USSR maintains a warning system in the Kamchatka-Kuril-Sakhalin region and can provide coverage for tsunamigenic earthquakes in that region as well as in northern Japan and the Western Aleutian Islands. It is expected that data from USSR will greatly enhance the efficiency of the Tsunami Warning System.

KEWEENAW BAY SEICHE

According to the Smithsonian Institute's Center for Short-Lived Phenomena, a seiche in Lake Superior on June 30, 1968, which has been described as a small tsunami, reached as high as seven feet in some areas. Boats along the Keweenaw Bay shoreline were washed ashore and were damaged. At the village of L'Anse, at the bottom end of the Bay, flooding of some houses occurred.

The phenomenon resulted when a strong low atmospheric pressure cell moved over part of the lake, causing water from the rest of the lake to surge into the low pressure area.

TSUNAMI WARNING SYSTEM COMMUNICATION PLAN CHANGES

Recent changes to the Communication Plan for the Tsunami Warning System have included the addition of the Acajutla, El Salvador tide station and the Moen Island, Truk Islands tide station to the System. Several agencies have been added to the list of those receiving Watch and Warning information and numerous address and communication changes were reported.

TSUNAMI CONFERENCE - OCD Region 8

On December 4, 1968, the U.S. Office of Civil Defense, Region 8, held a Seismic Sea Wave Warning Conference at Everett, Washington. Present at this conference were OCD Regional and State officials from Alaska, Oregon, and Washington, representatives from the Coast and Geodetic Survey, and communication personnel representing the FAA, Navy, and Coast Guard. Current warning procedures and responsibilities were discussed as well as problems peculiar to Region 8. Recommendations made as a result of these discussions included the following: establish a TWS tide station at Newport, Oregon; investigate the need for a stateside NAWAS drop at Palmer Observatory; Newport Observatory assume the responsibility for issuing seismic information messages to Region 8; current methods of communications involved in the transmission of warning information to regional and state officials in Alaska, Oregon, and Washington from Honolulu Observatory be explored; the States use pre-pared releases for the news media explaining in layman terms the nature of the tsunami hazard.

CHILE EARTHQUAKE OF DECEMBER 21, 1967 - TSUNAMI

According to Dr. C. Lomnitz of Ciudad University, Mexico, the earthquake of December 21, 1967, (02:25, Magn. 7.0) in North Chile may have been responsible for a minor tsunami in the port of Tocopilla. Local newspaper "El Mercurio" of December 22, 1967, refers to a "triple collision of ships in the port of Tocopilla, due to unusually heavy wave action." Tocopilla sustained about 20% damage from the earthquake which occurred earlier the same day but evidently the two phenomena were not thought to be connected.

TSUNAMI INVESTIGATIONS - AUGUST-SEPTEMBER-NOVEMBER-DECEMBER 1968

During the months of August, September, November, and December, 1968, the International Tsunami Information Center's Tsunami Warning System undertook the following investigations of possible tsunamigenic earthquakes:

Date & Time GMT	Epicenter	Magn. & Depth	Region	Comments
Sept 16, 1968 1355Z	6.1 S 148.7 E	6¼-6½ (PAS) 59 Km	New Britain Region	No evidence of tsunami

Epicenter	Magn. & Depth	Region	Comments
10.7 N 62.7 W	7.0 (PAS) 107 Km	Near coast of Venezuela	Possible tsunami on the north coast of Trinidad.. 2 killed, 37 injured from the earthquake.
42.2 N 142.6E	6.4 (CGS) 33 Km	Hokkaido, Japan	No evidence of tsunami
15.6 N 92.6 W	6.0 (PAS) 138 Km	Mexico - Guatemala	Possible 7-foot tsunami at Salina Cruz. 15 dead, 500 injured and heavy property damage from earthquake.
30.5 S 178.2 W	6.8 (CGS) 33 Km	Kermadec Islands	No evidence of tsunami
26.3 N 140.6 E	7.5 (PAS) 516	Bonin Islands	No evidence of tsunami
3.3 S 143.3 E	6.8 (CGS) 12 Km	North coast of New Guinea	Heavy property damage from earthquake. No evidence of tsunami
12.5 S 166.5 E	6.5 (PAS) 60 Km	Santa Cruz Is.	No evidence of tsunami
1.2 N 126.3 E	6.0 (CGS) Normal	Celebes Is.	No evidence of tsunami
3.4 S 145.9 E	6.5 (CGS) 15 Km	Near New Guinea	No evidence of tsunami
60.1 N 153.6 W	6.5 (PAS) 90 Km	Alaska	No evidence of tsunami